

## EVALUATING AND MANAGING THE IMPACT OF INDUCED SEISMICITY AT THE GEYSERS GEOTHERMAL FIELD

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### RESEARCH OBJECTIVES

As the demand for energy increases, it is obvious that geothermal resources must play a growing part in meeting our energy needs. Water injection into geothermal systems, to affect enhanced geothermal systems (EGS), has become an often-required strategy to extend and sustain production of geothermal resources. Critical questions that need to be addressed are how injection will affect seismicity of an area, what does seismicity imply for injection strategy, and how will seismicity and injection together impact the local community, as well as field operations.

The two prime objectives of this project are: (1) to understand the impact of EGS operations on induced seismicity and its environmental impact on the surrounding community, and (2) to use microearthquake monitoring to intelligently manage the effects of fluid injections and stimulations, so as to ensure the optimization of EGS projects.

### APPROACH

The Geysers, in Sonoma County, California, is a prime candidate for EGS because of its very high heat content— injection is one of the few economic means by which to mine the heat stored there in the subsurface rock. This site constitutes a unique opportunity for obtaining data before injection and increased production begin. Additional opportunities exist in the Basin and Range to monitor seismicity associated with hydrofracturing and using microearthquake (MEQ) monitoring to track the induced fracturing. In addition to natural fracture systems, hydrofracturing may be a possible means to enhance the fracture area and permeability of geothermal reservoirs. MEQ monitoring is a means to track the hydrofracture and estimate the success of the hydrofracturing operations.

Besides collecting data to address the environmental impact of EGS operations, we are also part of an International Energy Agency implementing agreement to participate in assessing and mitigating the environmental effects of these operations, specifically induced seismicity. The work scope of this international group is “to pursue a collaborative effort to address an issue of significant concern to the acceptance of geothermal energy in general, and EGS in particular. The objective is to investigate these (induced) events to obtain a better understanding of why they occur, so that they can either be avoided or mitigated. Understanding requires considerable effort to assess and generate an appropriate source-parameter model, testing of the model, and then calculating the source parameters in relation to the hydraulic injection history, stress field and the geological background. An interaction between stress modeling, rock mechanics, and source-parameter calculation is essential. Once the mechanism of the events is understood, the injection process, the creation of an engineered [enhanced] geothermal reservoir, or the extraction of heat over a prolonged period may need to be modified to reduce or eliminate the occurrence of large [seismic] events.”

### ACCOMPLISHMENTS

Data are being routinely gathered and analyzed in real time and sent to the U.S. Geological Survey for archiving. Figure 1, a typical map of a month's seismicity at The Geysers, shows the lack of seismicity in the northwest Geysers (Aidlin area), where injection has not yet started. Results will include a unique data set for a geo-thermal area, a set that will be available to the public and research community. Initial correlation has shown that although the numbers of events are increasing at The Geysers, the overall energy release is level or decreasing (do EGS areas eventually gain stability?). Also, as can be seen from Figure 1, the larger events occur outside of the main clusters (green stars).

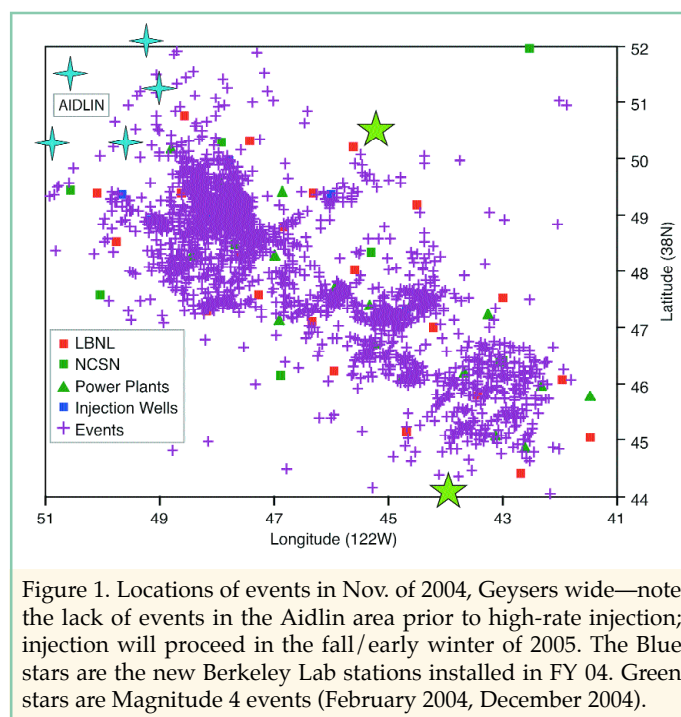


Figure 1. Locations of events in Nov. of 2004, Geysers wide—note the lack of events in the Aidlin area prior to high-rate injection; injection will proceed in the fall/early winter of 2005. The Blue stars are the new Berkeley Lab stations installed in FY 04. Green stars are Magnitude 4 events (February 2004, December 2004).

### SIGNIFICANCE OF FINDINGS

Never-before resolution and coverage will allow detailed analysis to correlate and investigate the link of induced seismicity to injection and production at The Geysers. Real-time public display will allow the community to gain confidence and assurance that the operators are acting in a responsible fashion.

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